

04-23-01

A

ASSISTANT COMMISSIONER FOR PATENTS
 PATENT APPLICATION
 Washington, D.C. 20231

DOCKET NO. JP920000446US1
 Date: April 20, 2001

J1036 U.S. PTO
 09/839097
 04/20/01

Transmitted herewith for filing is the Patent Application of:

Inventors: Ashish Verma, Abhinanda Sarkar, Arpita Ghosh

For: DECISION MAKING IN CLASSIFICATION PROBLEMS

Enclosed are:

☒ 3 Sheets of Formal Drawings.

☒ An assignment of the invention to International Business Machines Corporation, Armonk, New York 10504.

☐ A certified copy of a _____ application, dated _____, no. _____.

☒ Executed Declaration and Power of Attorney is attached to the application.

☐ Associate Power of Attorney.

☐ Information Disclosure Statement with form PTO-1449 with references attached.

The filing fee has been calculated as shown below:

	(Col. 1)	(Col. 2)
FOR:	NO. FILED	NO. EXTRA
BASIC FEE	13 - 20 = 0	
TOTAL CLAIMS	13 - 20 =	0
INDEP CLAIMS	3 - 3 =	0
____ MULTIPLE DEPENDENT CLAIM PRESENTED		

OTHER THAN A SMALL ENTITY	
RATE	FEE
13 - 20 = 0	\$ 710.00
X \$ 18 =	\$ 0.00
X \$ 80 =	\$ 0.00
+ \$ 270 =	\$ 0.00
TOTAL	\$ 710.00

If the difference in Col. 1 is less than zero, enter "0" in Col. 2.

☒ Please charge my Deposit Account No. 09-0468 in the amount of \$ 710.00.

☒ The Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 09-0468. A duplicate copy of this sheet is enclosed.

☒ Any additional filing fees required under 37 CFR 1.16.

☒ Any patent application processing fees under 35 CFR 1.17.

Respectfully submitted,

By 

Manny Schecter
 Registration No.: 31,722
 Tel. (914) 945-3252

IBM CORPORATION
 INTELLECTUAL PROPERTY LAW DEPT.
 P.O. BOX 218
 YORKTOWN HEIGHTS, NY 10598

Express Mail EL627131289US
 Date of Deposit: Apr. 20, 2001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Ashish Verma, et al.

Serial No.:

Group No.

Filed: Herewith

Examiner:

For: DECISION MAKING IN CLASSIFICATION PROBLEMS

Assistant Commissioner of Patents and Trademarks
Washington, D.C. 20231

EXPRESS MAIL CERTIFICATE

Express Mail Label Number EL627131289US

Date of Deposit April 20, 2001

I hereby certify that the attached paper or fee

Acknowledgement Postcard

Patent Application Transmittal Letter (original and one copy)

Patent Application

Executed Declaration and Power of Attorney

Informal Drawings (3 Sheets)

Assignment to IBM with Recordation Form

is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Kathy Cognatello

(Name)

Kathy Cognatello

Signature

Note: Each paper must have its own certificate and the "Express Mail" label number as a part thereof or attached thereto. When, as here, the certification is presented on a separate sheet, that sheet must (1) be signed and (2) fully identify and be securely attached to the paper or fee it accompanies. Identification should include the serial number and filing date of the application as well as the type of paper being filed, e.g. complete application, specification and drawings, responses to rejection or refusal, notice of appeal, etc. If the serial number of the application is not known, the identification should include at least the name of the inventor(s) and the title of the invention.

Note: The label number need not be placed on each page. It should, however, be placed on the first page of each separate document, such as, a new application, amendment, assignment, and transmittal letter for a fee, along with the certificate of mailing by "Express Mail". Although the label number may be on checks, such a practice is not required. In order not to deface formal drawings it is suggested that the label number be placed on the back of each formal drawing or the drawings be accompanied by a set of informal drawings on which the label number is placed.

Docket No. JP920000446US1

DECISION MAKING IN CLASSIFICATION PROBLEMS

Field of the Invention

The invention relates to decision making in classification problems and relates particularly, though not exclusively, to improved methods of classification in decision fusion applications.

Background of the Invention

Decision fusion is a widely used technique for several kinds of classification applications such as, for example, medical imaging, biometric verification, signature or fingerprint recognition, robot vision, speech recognition, image retrieval, expert systems etc.

Generally, in decision fusion applications, multiple classifiers (or experts) perform separate classification experiments on respective data sets, and consequently designate a nominated class as correct. The classifier decisions are then combined in a predetermined selection strategy to arrive at the final class, as described below. Two extreme approaches for the combination strategy are outlined below:

1. The first approach may accept the decision of the majority of the classifiers as the final decision (decision consensus approach).
2. The second approach can take the decision of the most competent expert as the final decision (most competent expert approach).

An intermediate approach involves determining a solution in which a consensus decision is evaluated in terms of the past track records of the experts. Instead of directly accepting the consensus decision, the reliability of each decision is evaluated through various kinds of confidence measures. The decision is either accepted or rejected based on the result of such an evaluation.

In a further approach, a Bayesian cost function is minimised over all the decisions given by the experts. The cost function is defined as the cost of making a wrong decision

multiplied by the joint probability of occurrence of the respective decisions.

None of the above approaches outlined above are rigorously optimal or universally applicable, and can be subject to errors or limitations of one kind or another. Accordingly, it is an object of the invention to at least attempt to address these and other limitations associated with the prior art. In particular, it is an object of the invention to generally improve the classification accuracy of particular decision fusion applications which rely on one of the prior art approaches outlined above.

Summary of the Invention

The inventive concept is founded in recognition that the reliability of a classifier in a decision fusion architecture can vary from sample to sample and from experiment to experiment. The inventive concept involves using the decisions from multiple classifiers in a decision fusion application to make an informed decision as to the classifier which is likely to be correct.

More particularly, the inventive concept resides in a recognition that a strategy of assigning confidences to different classifiers in a decision fusion architecture can be used to improve the classification accuracy of a decision fusion application. This inventive strategy is thought to result in improved classification accuracy.

Embodiments of the invention involve attempting to optimally adapt the weight given to a particular classifier from sample to sample, which generally results in improved performance compared with prior art approaches. A weight or metric of relative confidence is assigned to every classifier, depending upon its sample confidence and overall confidence (as subsequently described). For each class, an overall score (or likelihood) is calculated which combines individual scores from all classifiers, which allows the class with the highest score (or likelihood) to be designated as the correct class.

The invention provides a method suitable for deciding how to classify a sample in one of a number of predetermined classes, the method comprising:

(a) associating a weight w_{ij} with each of a plurality of classifiers i which are class models for how to classify a sample j in one of a number of predetermined classes k ;

(b) calculating for each of said predetermined classes k a weighted summation CL_{jk} across said classifiers i of the likelihood l_{ijk} that the sample belongs to that respective class k , weighted by the weight w_{ij} ; and

(c) designating the sample j as belonging to the class k which has an associated weighted summation of likelihoods CL_{jk} which is greatest in value.

The invention further provides an apparatus for classifying a data sample in one of a number of predetermined classes, the apparatus comprising: input means to receive data; and processor means for calculating associating a weight w_{ij} with each of a plurality of classifiers i which are class models for how to classify a sample j in one of a number of predetermined classes k , and for designating calculating for each of said predetermined classes k a weighted summation CL_{jk} across said classifiers i of the likelihood l_{ijk} that the sample belongs to that respective class k , weighted by the weight w_{ij} . The weight can be derived from a metric of relative confidence in the decision of a respective classifier i . Preferably, this is an L-statistic (linear combination of the order statistic), which represents the statistical separation among the order statistic, preferably log-likelihoods, against the class models for a classifier.

This determination of relative confidence can be performed in two different ways to calculate two components of weight given to the decision of a classifier i , referred to as sample confidence L_{ij} and overall confidence H_i . Preferably, these confidence values of the classifiers i are subsequently used to combine the decisions from the classifiers i to obtain the final decision.

The L-statistic, for a particular sample j , L_{ijk} , can be defined as:

$$L_{ij} = a_1 l_{ij1} + a_2 l_{ij2} + \dots + a_n l_{ijn}$$

where l_{ijk} denotes for sample j and classifier i , the log-likelihood of the k th most likely class is such that the l_{ijk} s form order statistic, that is $l_{ij1} > l_{ij2} > \dots > l_{ijn}$. The values of a_i s define the

form of the particular L-statistic L_{ij} chosen. Preferably, the order statistic used is simply the difference between the log-likelihoods of the two most likely classes k . That is, $a_1 = 1$, $a_2 = -1$ and all other $a_s = 0$.

5 A cumulative mean H_i of the sample confidence L_{ij} over a large number of samples is used to measure the overall discrimination capability of the classifier. It is currently

$$H_i = \sum_{j=1}^t L_{ij}/t$$

understood that the value of the overall confidence H_i so calculated converges to a constant value which

is well separated for different overall confidence levels.

10 Overall confidence for classifier i , H_i , is computed as cumulative mean or moving average of the L-statistic L_{ij} over a number of samples j after which it becomes almost constant.

15 In the equation directly above t is the number of samples after which the overall confidence value stabilises. H_i attempts to model some kind of disturbance or noise which is application specific. Typically, such noise degrades the efficiency of the classifier across all classes. For example, in the case of speech recognition, this may be ambient noise (such as car noise, cocktail party noise) present in the audio channel. There may be, of course, some
20 cases in which the amount of noise present in the classifier varies during the experiment.

For every incoming sample j , sample confidence values L_{ij} s are computed for every classifier i . The overall confidence H_i for the classifiers are updated using L_{ij} . Preferably, a weight w_{ij} is assigned to each classifier i as a function of the overall confidence H_i and the sample confidence L_{ij} . Once weights w_{ij} for each classifier are known, each incoming sample
25 j can be classified in a class k by calculating the combined log-likelihood CL_{jk} for each class k , as set out directly below.

where

$$w_{ij} = f(L_{ij}, H_i)$$

For the sample j , the class k with the highest calculated combined log-likelihood CL_{jk} is finally chosen as the correct class k for sample j . The l_{ijk} denotes the log likelihood of sample j for class k using classifier i .

The invention also includes a computer program product for performing embodiments of the inventive methods described above.

Embodiments of the invention can be used in various applications in which decision fusion is conventionally used.

Brief Description of the Drawings

Fig. 1 is a schematic representation of the process involved in reaching a decision in a classification problem, in accordance with an embodiment of the invention.

Fig. 2 is a schematic representation of the process involved in determining a weight using a threshold value, in accordance with an embodiment of the invention.

Fig. 3 is a schematic representation of computing hardware suitable for performing embodiments of the invention.

Detailed Description of Embodiments and Best Mode

An embodiment of the invention is described below in the context of an audiovisual speech recognition application which uses decision fusion for classification problems. In this context, there are two relevant classifiers: audio and video.

In overview, the classification or recognition process initially involves steps as outlined in Fig. 1. Initially, in step 10, the process involves associating a metric of relative

confidence with respective classifiers or class models which predict how a sample should be recognised. The L_{ij} is calculated in step 20 as an L-statistic of the log-likelihoods l_{ijk} , as detailed below. The moving average H_i , across a suitable number of samples j is then determined in step 30. This allows weights W_i to be calculated in step 40 for each classifier from H_i and L_{ij} , according to a suitable function as detailed below. The combined likelihoods across classifiers CL_{jk} are then calculated in step 50 as a weighted summation of the likelihoods of each class, so that the most likely class can then be determined in step 60.

For the speech recognition application decision, the problem can be defined as follows. Given an audio and a video vector corresponding to a particular speech time frame, it is necessary to determine the phone class to which this frame belongs. Phones are modelled as GMM (Gaussian Mixture Models) obtained from the training data.

Given an audio vector, its likelihood of corresponding to each of the phone classes is computed from the respective classification models. From these likelihoods, the L-statistic is preferably chosen simply as the difference between the first and the second most likely choices. As a result, coefficients a_i are used as follows.

$$a_1 = 1, a_2 = -1, \text{ all other } a_i = 0$$

A similar computation is also performed for the video vector. The L-statistic is shown as L_{ij} in Fig. 2. The cumulative mean of L-statistic, H_i is used here to model the background noise present in the audio channel only, as background noise uniformly degrades the audio recognition rate across all phonetic sounds. Accordingly, the L-statistic L_{ij} decreases uniformly in the presence of noise. The combined likelihood of corresponding to a particular phone class is computed as follows.

$$CL_i = w_a * l_{ai} + w_v * l_{vi}$$

Here l_{ai} and l_{vi} are log likelihoods for i th audio class and i th video class respectively, w_a and w_v are the weights assigned to the audio and video likelihoods respectively. The phone class with the highest combined likelihood is selected as the correct phone class.

The weight for audio is determined and, since there are only two classifiers in this case, the weight for video is simply determined as the complement of the weight for audio, as the linear summation of all weights is 1. A threshold a_t is defined for sample confidence values of audio which are just the L-statistic in this case. First, the class confidence value for audio is checked against its threshold in step 100. If it passes this test, audio weight is computed in step 110 as a constant term and a term which is dependent on the overall confidence of the audio channel. If audio fails this test in step 120, the constant term in the weight changes.

Hence this embodiment, function $f()$ is implemented as

$$w_{ij} = f(L_{ij}, H_i) = f_1(L_{ij}) + f_2(H_i)$$

where $f_1()$ is chosen as a threshold function and $f_2()$ is given as

$$f_2(H_i) = x_1 / (1 + \exp(x_2 * H_i))$$

Parameters x_1 and x_2 are scalar values that are selected and, if necessary, adjusted to provide good performance. Preferably, sample confidence is used as a confidence measure for a classifier for the current sample being processed. The sample confidence models non-uniform discrimination capability of the classifier across various classes due to the non-uniform dispersion of the clusters in vector space for the data set of the classifier. The sample confidence does not represent the overall discrimination capability of the classifier. A low value of the sample confidence indicates low confidence in its decision for the present sample. Similarly, a high value of the sample confidence indicates a higher confidence in its decision for that sample. The sample confidence for the present sample is preferably represented by the L-statistic for the sample.

Preferably, overall confidence represents the overall discrimination capability of the classifier across all classes (or clusters). This overall discrimination capability may vary between experiments degraded due to the presence of noise which uniformly degrades the classifier's discrimination capability across all classes. For example, in the case of speech

recognition, this may be background noise present in the audio channel.

In this application, it is possible to achieve improvements in phonetic classification results using the techniques of the described embodiment of the invention.

Computer hardware for performing embodiments of the invention is now described.

5 The described process of classification can be implemented using a computer program product in conjunction with a computer system 200 as shown in Fig. 3. In particular, the process can be implemented as software, or computer readable program code, executing on the computer system 200.

10 The computer system 200 includes a computer 250, a video display 210, and input devices 230, 232. In addition, the computer system 200 can have any of a number of other output devices including line printers, laser printers, plotters, and other reproduction devices connected to the computer 250. The computer system 200 can be connected to one or more other computers via a communication input/output (I/O) interface 264 using an appropriate communication channel 240 such as a modem communications path, an electronic network, or the like. The network may include a local area network (LAN), a wide area network (WAN), an Intranet, and/or the Internet 220.

15 The computer 250 includes the control module 266, a memory 270 that may include random access memory (RAM) and read-only memory (ROM), input/output (I/O) interfaces 264, 272, a video interface 260, and one or more storage devices generally represented by the storage device 262. The control module 266 is implemented using a central processing unit (CPU) that executes or runs a computer readable program code that performs a particular function or related set of functions.

20 The video interface 260 is connected to the video display 210 and provides video signals from the computer 250 for display on the video display 210. User input to operate the computer 250 can be provided by one or more of the input devices 230, 232 via the I/O interface 272. For example, a user of the computer 250 can use a keyboard as I/O interface 230 and/or a pointing device such as a mouse as I/O interface 232. The keyboard and the

mouse provide input to the computer 250. The storage device 262 can consist of one or more of the following: a floppy disk, a hard disk drive, a magneto-optical disk drive, CD-ROM, magnetic tape or any other of a number of non-volatile storage devices well known to those skilled in the art. Each of the elements in the computer system 250 is typically connected to other devices via a bus 280 that in turn can consist of data, address, and control buses.

The method steps for are effected by instructions in the software that are carried out by the computer system 200. Again, the software may be implemented as one or more modules for implementing the method steps.

In particular, the software may be stored in a computer readable medium, including the storage device 262 or that is downloaded from a remote location via the interface 264 and communications channel 240 from the Internet 220 or another network location or site. The computer system 200 includes the computer readable medium having such software or program code recorded such that instructions of the software or the program code can be carried out. The use of the computer system 200 preferably effects advantageous apparatuses for constructing a runtime symbol table for a computer program in accordance with the embodiments of the invention.

The computer system 200 is provided for illustrative purposes and other configurations can be employed without departing from the scope and spirit of the invention. The foregoing is merely an example of the types of computers or computer systems with which the embodiments of the invention may be practised. Typically, the processes of the embodiments are resident as software or a computer readable program code recorded on a hard disk drive as the computer readable medium, and read and controlled using the control module 266. Intermediate storage of the program code and any data including entities, tickets, and the like may be accomplished using the memory 270, possibly in concert with the storage device 262.

In some instances, the program may be supplied to the user encoded on a CD-ROM or a floppy disk (both generally depicted by the storage device 262), or alternatively could be

read by the user from the network via a modem device connected to the computer 250. Still further, the computer system 200 can load the software from other computer readable media. This may include magnetic tape, a ROM or integrated circuit, a magneto-optical disk, a radio or infra-red transmission channel between the computer and another device, a computer
5 readable card such as a PCMCIA card, and the Internet 220 and Intranets including email transmissions and information recorded on Internet sites and the like. The foregoing are merely examples of relevant computer readable media. Other computer readable media may be practised without departing from the scope and spirit of the invention.

Further to the above, the described methods can be realised in a centralised fashion
10 in one computer system 200, or in a distributed fashion where different elements are spread across several interconnected computer systems.

Computer program means or computer program in the present context mean any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either
15 directly or after either or both of the following: a) conversion to another language, code or notation or b) reproduction in a different material form.

In the foregoing manner, a method, an apparatus, and a computer program product for are disclosed. While only a small number of embodiments are described, it will be apparent to those skilled in the art in view of this disclosure that numerous changes and/or
20 modifications can be made without departing from the scope and spirit of the invention.

It is understood that the invention is not limited to the embodiment described, but that various alterations and modifications, as would be apparent to one skilled in the art, are included within the scope of the invention.

We claim:

1. A method suitable for deciding how to classify a sample in one of a number
5 of predetermined classes, the method comprising:

(a) associating a weight w_{ij} with each of a plurality of classifiers i which are
class models for how to classify a sample j in one of a number of predetermined classes k ;

(b) calculating for each of said predetermined classes k a weighted summation
 CL_{jk} across said classifiers i of the likelihood l_{ijk} that the sample belongs to that respective
10 class k , weighted by the weight w_{ij} ; and

(c) designating the sample j as belonging to the class k which has an associated
weighted summation of likelihoods CL_{jk} which is greatest in value.

2. The method as claimed in claim 1, wherein the weight w_{ij} is derived from a
15 metric of relative confidence L_{ij} , metric of relative which is calculated as an L-statistic, or
linear combination of an order statistic, which represents the statistical separation among an
order statistic of the classes k for a particular classifier i .

3. The method as claimed in claim 2, wherein the L-statistic L_{ij} is of the
20 log-likelihoods of respective classes k for classifiers i .

4. The method as claimed in claim 2, wherein the L-statistic L_{ij} , for a
particular sample j , is calculated as: $L_{ij} = a_1 l_{ij1} + a_2 l_{ij2} + \dots + a_n l_{ijn}$, where l_{ijks} form order
statistic, that is $l_{ij1} > l_{ij2} > \dots > l_{ijn}$ and $a_1 = 1$, $a_2 = -1$ and all other $a_s = 0$.

25

5. The method as claimed in claim 2, wherein the weight w_i derived from the
metric of relative confidence is calculated as a function of (a) sample confidence L_{ij} , equal to

the L-statistic L_{ij} and (b) overall confidence H_i , the cumulative mean of the sample confidence L_{ij} over a plurality of samples j .

6. The method as claimed in claim 5, wherein the overall confidence H_i is successively updated with the sample confidence L_{ij} of each sample j .

7. A computer program product having a computer readable medium having a computer program recorded therein for deciding how to classify a sample in one of a number of predetermined classes, said computer program product comprising:

(a) code means for associating a weight w_{ij} with each of a plurality of classifiers i which are class models for how to classify a sample j in one of a number of predetermined classes k ;

(b) code means for calculating for each of said predetermined classes k a weighted summation CL_{jk} across said classifiers i of the likelihood l_{ijk} that the sample belongs to that respective class k , weighted by the weight w_{ij} ; and

(c) code means designating the sample j as belonging to the class k which has an associated weighted summation of likelihoods CL_{jk} which is greatest in value.

8. An apparatus for classifying a data sample in one of a number of predetermined classes, the apparatus comprising: input means to receive data; and processor means for calculating associating a weight w_{ij} with each of a plurality of classifiers i which are class models for how to classify a sample j in one of a number of predetermined classes k , and for designating calculating for each of said predetermined classes k a weighted summation CL_{jk} across said classifiers i of the likelihood l_{ijk} that the sample belongs to that respective class k , weighted by the weight w_{ij}

9. The apparatus as claimed in claim 8, wherein the weight w_{ij} is derived from a metric of relative confidence L_{ik} metric of relative which is calculated as an L-static, or linear combination of an order statistic, which represents the statistical separation among an order statistic of the classes k for a particular classifier i .

10. The apparatus as claimed in claim 9, wherein the L-statistic L_{ij} is of the log-likelihoods of respective classes k for classifiers i .

11. The apparatus as claimed in claim 9, wherein the L-statistic L_{ij} , for a particular j , is calculated as: $L_{ij} = a_1 l_{ij1} + a_2 l_{ij2} + \dots + a_n l_{ijn}$, where l_{ijk} s form order statistic, that is $l_{ij1} > l_{ij2} > \dots > l_{ijn}$ and $a_1 = 1$, $a_2 = -1$ and all other $a_s = 0$.

12. The apparatus as claimed in claim 9, wherein the weight w_i derived from the metric of relative confidence is calculated as a function of (a) sample confidence L_{ij} , equal to the L-statistic L_{ij} and (b) overall confidence H_i , the cumulative mean of the sample confidence L_{ij} over a plurality of samples j .

13. The apparatus as claimed in claim 12, wherein, the overall confidence H_i is successively updated with the sample confidence L_{ij} of each sample j .

ABSTRACT

A method of classifying samples to one of a number of predetermined classes involves using a number of class models or classifiers to form order statistic for each classifier. A linear combination of the order statistic (L-statistic) is calculated to determine the confidence of that particular classifier, both in general and for that particular sample. Relative weights are then derived from these confidences, and used to calculate a weighted summation across all classifiers for each class of the likelihoods that a sample belongs to that class. The sample is classified in the class which has the associated weighted summation which is greatest in value.

T00240-606660

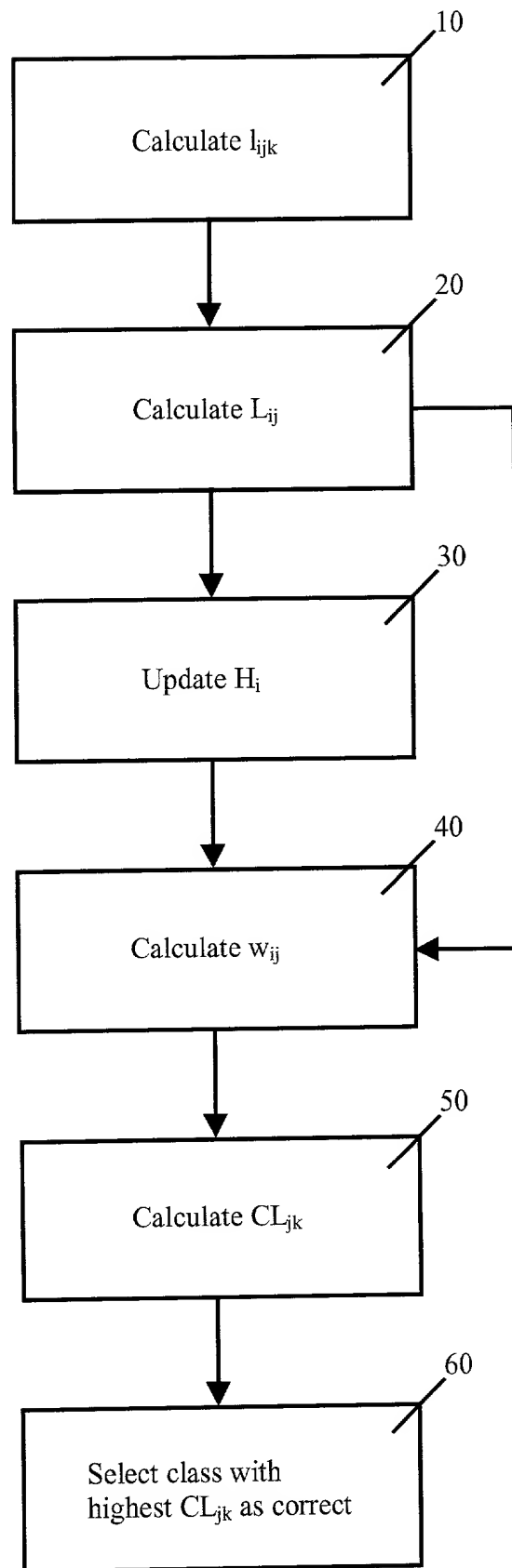
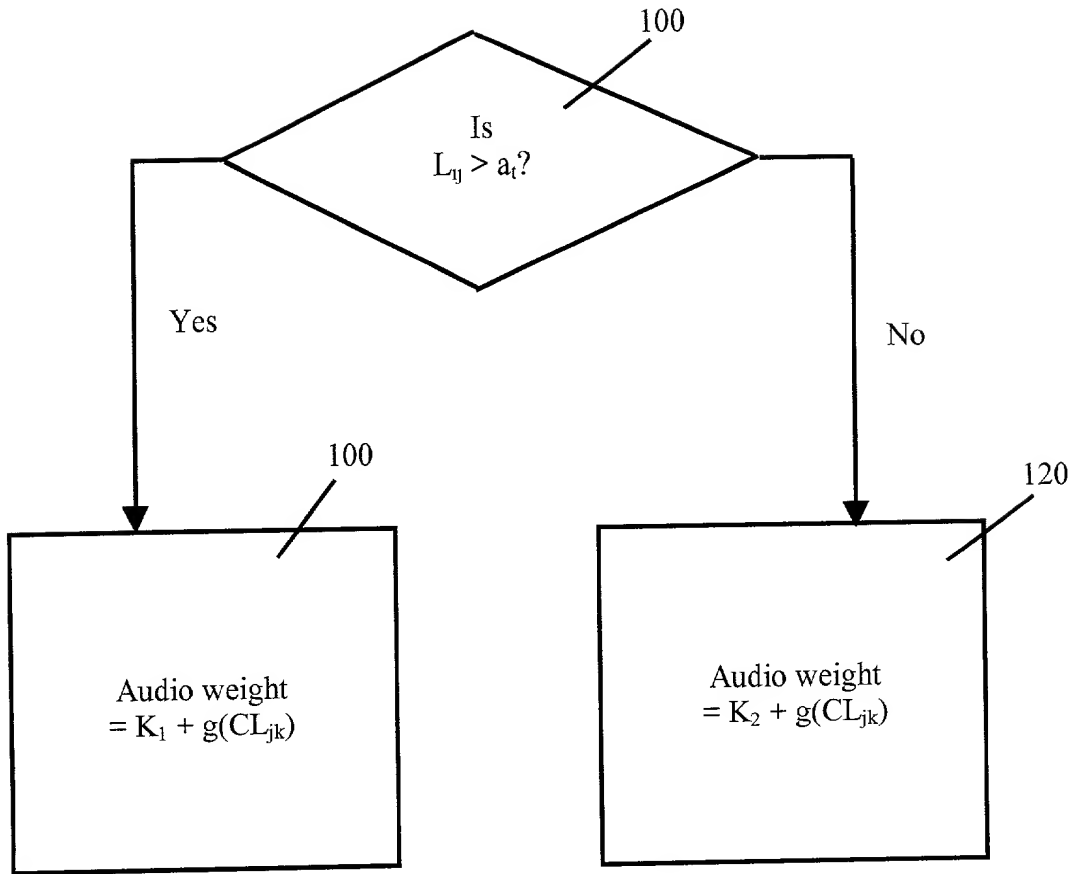


FIG. 1

**FIG. 2**

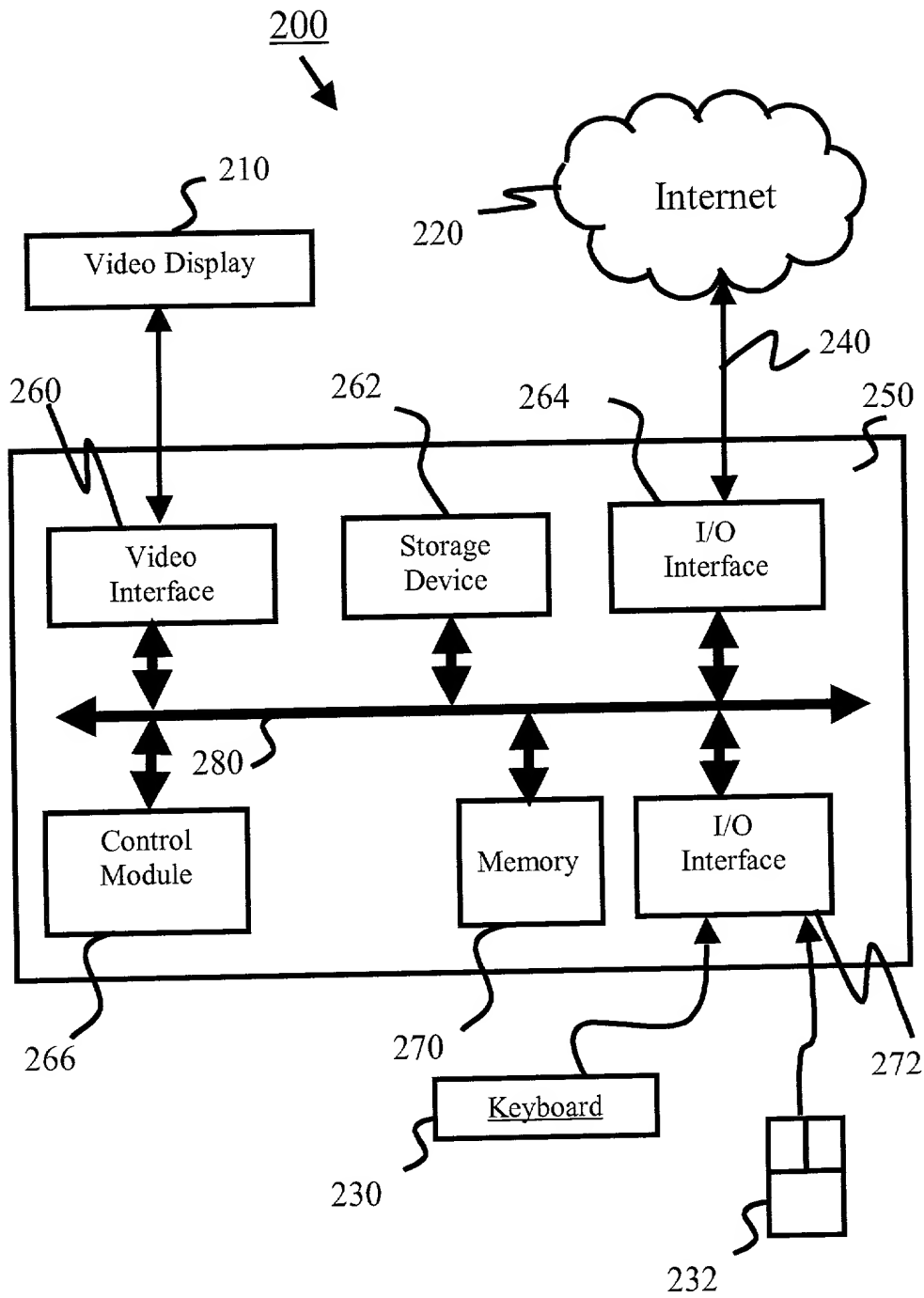


FIG. 3

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

DECISION MAKING IN CLASSIFICATION PROBLEMS

the specification of which (check one)

☒ is attached hereto.

_____ was filed on _____ as

Application Serial No. _____

and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
_____	_____	_____	_____	_____
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
_____	_____	_____	_____	_____
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
_____	_____	_____	_____	_____
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States provisional application(s) listed below.

_____ (Application Number) _____ (Filing Date)

_____ (Application Number) _____ (Filing Date)

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States Application(s) listed below and, insofar as the subject matter of each of the claims of the application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose information material to the patentability of this application as defined in Title 37, Code of Federal Regulations, Section 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application;

_____ (Application Serial No.)	_____ (Filing Date)	_____ (Status) (patented, pending, abandoned)
_____ (Application Serial No.)	_____ (Filing Date)	_____ (Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number).

Manny W. Schecter (Reg. 31,722), Terry J. Ilardi (Reg. 29,936), Christopher A. Hughes (Reg. 26,914), Edward A. Pennington (Reg. 32,588), John E. Hoel (Reg. 26,279), Joseph C. Redmond, Jr. (Reg. 18,753), Kevin M. Jordan (Reg. 40,277), Stephen C. Kaufman (Reg. 29,551), Jay. P. Sbrollini (Reg. 36,266), David M. Shofi (Reg. 39,835), Robert M. Trepp (Reg. 25,933), Louis P. Herzberg (Reg. 41,500), and Douglas W. Cameron (Reg. 31,596), Paul Otterstedt (Reg. 37,411), Louis J. Percello (Reg. 33,206) and Daniel P. Morris (Reg. 32,053).

[I\ELEC\IBM\522990US]dec doc dmp

Express Mail EL627131289US
Date of Deposit: Apr. 20, 2001

Send Correspondence to: Stephen C. Kaufman
IBM Corporation (39-239)
PO Box 218
Route 134 Kitchawan Road, Yorktown Heights, NY 10598
Direct Telephone Calls to: Stephen C. Kaufman, 914-945-3197

Full name of original, first and joint inventor Ashish Verma

Inventor's Signature Ashish Verma Date March 23, 2001

Residence A-92, Shivalik Colony, New Delhi - 110 017

Citizenship India

Post Office Address A-92, Shivalik Colony, New Delhi - 110 017, India

Full name of original, first and joint inventor Abhinanda Sarkar

Inventor's Signature Abhinanda Sarkar Date 26/03/2001

Residence N-86, Panchsheel Park, New Delhi - 110 017

Citizenship India

Post Office Address N-86, Panchsheel Park, New Delhi - 110 017, India

Full name of original, first and joint inventor Arpita Ghosh

Inventor's Signature Arpita Ghosh Date 23 MARCH 2001

Residence 7-B, Annapurna, Anushakti Nagar, Mumbai - 400 094

Citizenship India

Post Office Address 7-B, Annapurna, Anushakti Nagar, Mumbai - 400 094, India